OPTICAL PROCESSING:

POWER RESPONSE OF A MODULATED GENERAL OPTICAL SYSTEM

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The power response of a modulated optical system is obtained in terms of a general integral expression. Applications to particular systems such as monomode fibers, and to electrical bandwidth measurements are given as example.

We consider the general system shown in figure 1, which includes: An optical source $b(t)$, a modulator $g(t)$, and an optical system with a transfer function given by $H(w,z)$, where $H(w,o)= 1$. If $U(0,t)$ and $U(z,t)$ stand respectively for the fields at the optical system input and output, and if we take into account that Maxwell equations are linear, we have

$$U(z,t)= U(0,t) * h(z,t) = (b(t)g(t)) * h(z,t) = \\ = F^{-1}[(B(w)*G(w))(H(w,z))] \tag{1}$$

F^{-1} stands for the inverse Fourier transform, and $*$ is the convolution operator.

From (1) and F^{-1} definition we have

$$U(z,t)= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} H(w,z) \left[\int_{-\infty}^{\infty} G(u-w)\, B(w)\, dw \right] \exp[-jut]\, du \tag{2}$$

Multiplying (2) by its complex conjugate and considering

$$< B(w)\, B^*(w') > \; = P(w')\, \delta(w'-w) \; , \tag{3}$$

we obtain

$$< |U(z,t)|^2 > \; = \frac{1}{2\pi} \int_{-\infty}^{\infty} P(w)\, |R(z,w,t)|^2\, dw \tag{4}$$

being

$$R(z,w,t) = \int_{-\infty}^{\infty} G(u-w)\, H(u,z) \exp[-jut]\, du \tag{5}$$

The first application is related with monomode waveguides, and constant attenuation, being

$$H(w,z)= \exp[j\beta(w)z] \tag{6}$$

and

$$R(z,w,t)= \int_{-\infty}^{\infty} G(u-w) \exp[j(\beta(w)z-ut)]\, du \tag{7}$$

This expression was found by Wang [1], and Marcuse [2], and has been used in the analysis of pulse sequence propagation [1,2]. In the case of non-constant attenuation

$$R(z,w,t) = \int_{-\infty}^{\infty} G(u-w) \exp\left[j\,\beta(w)z - \frac{\alpha(w)}{2} - jut \right] du \tag{8}$$

The second application is involved with the electrical bandwidth measurement of the whole system. The modulating signal must be a tone, therefore

$$g(t) = A \cos W_e t \tag{9}$$

If $\quad H(w,z) = |H(w,z)| \exp |j\,\phi(w,z)|$

we have for the coherent source,

$$P(w) = I_o\, \delta(w-w_o),$$

the electrical bandwidth

$$|H_e(W_e,z)| = \frac{I_o}{2\pi} |H(w_o + W_e,z)|\; |H(w_o-W_e,z)|$$

and for the incoherent source

$$P(w) = I_o$$

$$|H_e(W_e, z)| = \frac{I_o}{2\pi} R_{HH}(2W_e) .$$

Where $R_{HH}(\tau)$ is the optical transfer function auto-correlation

REFERENCES

|1| Wang, Ch.: "Transmission of a gaussian pulse in singlemode fiber systems", Journal of Lightwave Technology, LT-1, 4, 572-579, (1983).

|2| Marcuse, D.: "Pulse distortion in singlemode fibers", App.Opt., 19, 1653-1660, (1980).

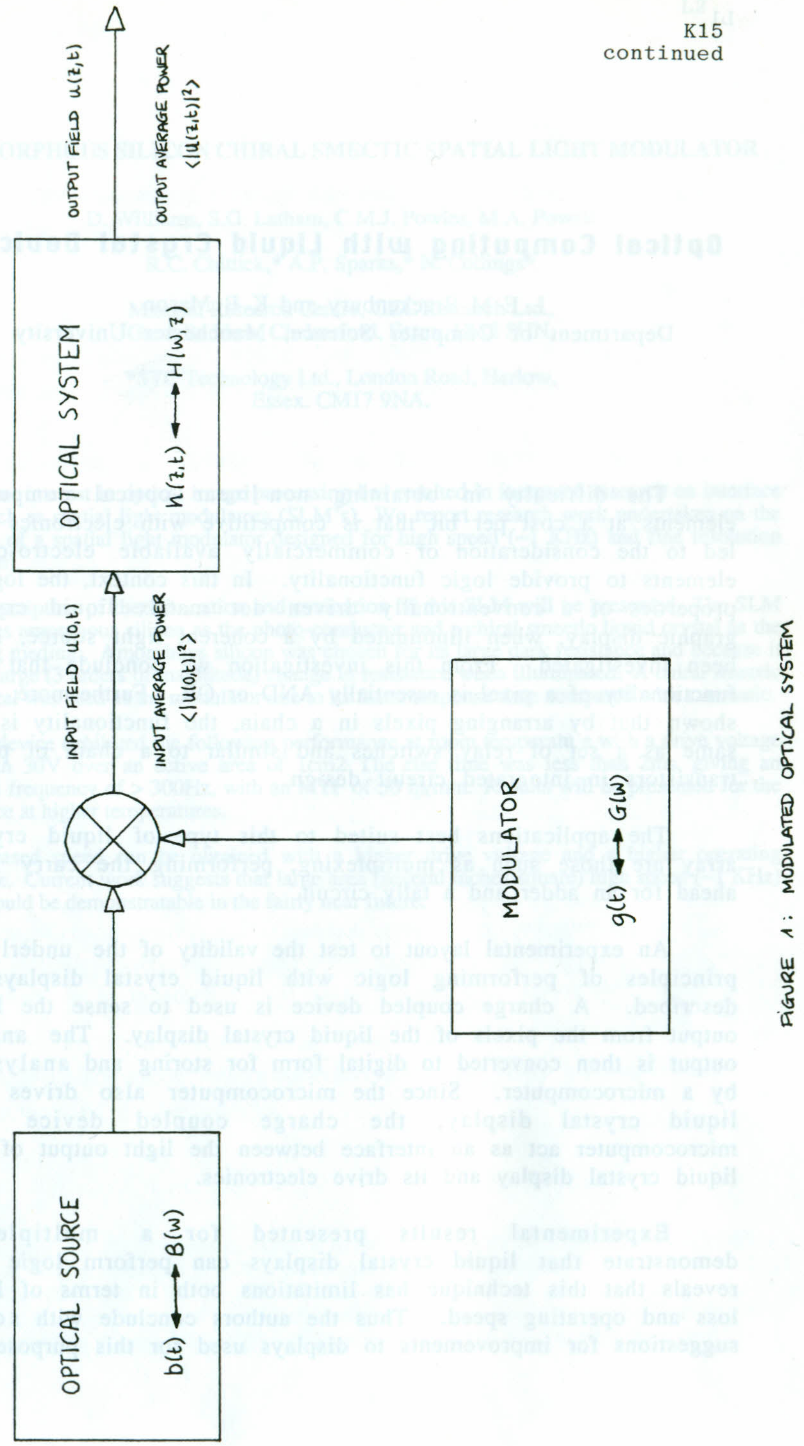

FIGURE 1: MODULATED OPTICAL SYSTEM